EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

Reports from stakeholder meetings

Notes of a meeting held at The Royal Academy of Engineering on 7 March 2011.

This report summarizes the discussions of a consultation about computing in schools held at the Royal Academy of Engineering (the Academy) on March 7th 2011. The meeting of invited Academy Fellows and experts from schools was organised as a contribution to an ongoing Royal Society (RS) study about computing in schools. The aim was to seek the views of employers and universities about the relevance of current computer studies provision in schools and colleges and whether it meets the needs of higher education and employers (including industry). The meeting began with introductory remarks about the background to the RS study, the qualifications landscape of computing in schools and the role extra-curricular activities might play in motivating and engaging young people. This provided the background and context for two main workshop discussions. The first considered the needs of employers and universities when recruiting to IT and the balance between general and technical IT skills needed in different settings. The second looked at the relevance of the learning outcomes of a range of popular ICT and computing qualifications for 14-19 year olds. Points from the discussions were brought together in a final plenary session which considered the fitness for purpose of present day school qualifications in relation to the skills needs of employers and higher education.

Introduction

Opening remarks introduced the background to the RS study and Academy consultation, providing an overview of computing in schools and introduced ideas about extra-curricular enrichment.

Background (Steve Furber)

Between 2003 and 2009 the take up of A level computing in school fell by 60 per cent. This was mirrored by a decline in applications to computer studies and related courses at university level. The Royal Society was prompted to propose a study by the concern this aroused and by requests from a range of organizations including the Academy. The study began with an open call for evidence in 2010 which received 120 responses indicating widespread interest and covering issues such as the supply of specialist teachers and the extent to which teachers are supported through professional development. Additional research was being commissioned and a series of stakeholder engagement meetings in addition to the Academy's event were being organised, including events specifically aimed at teachers. The Academy consultation was organized to feed into the study by providing a specific focus on issues of 'supply and demand' in industry and higher education although this focus was not intended to preclude discussion of wider issues on the day.

Terminology (Martin Smith)

A potential difficulty for exploring issues in the field is presented by the wide range of technical terms which vary in use and meaning in different settings. A working terminology has been proposed to clarify discussions. The term ICT is taken to mean the skills used in the general application of computer technology and the use of computers. Computing (also referred to as computer science) is used to mean the science of computing including computer design, algorithms and programming. There is currently no single taxonomy covering the range of different job roles in the IT industry and one of the aims of the Academy discussion is to clarify the balance between ICT and computing skills required in different areas.

Computing in Schools (Mandy Honeyman)

In the last decade there have been two major changes in the school curriculum affecting the computing landscape in schools. Labour's National Curriculum Review in 2000 restricted ICT to provision bounded by specific lesson plans designed to be taught by a teaching workforce largely lacking in ICT skills. It identified 5 main strands of ICT: communicating, handling, controlling, monitoring and measuring.

The findings of the 2004 Tomlinson Report proposed the introduction of a type of British Baccalaureate providing all pupils with a mix of academic and vocational skills. In response the Labour government introduced a range of new vocational diplomas at Key Stages 4 and 5 alongside a requirement for functional skills in ICT, English and mathematics.

The current situation of ICT and computing in schools is confused and in a state of flux:

- The new curriculum, introduced in 2009 allowed a more flexible approach to teaching ICT with 3 main strands consisting of: Planning, developing and evaluating, Handling data, sequencing instructions and modelling and Finding, using and communicating information. But this may not have been fully adopted by teachers as it was not a requirement to put this into place until September 2010. This new curriculum would have allowed teachers to develop computing programmes of study.
- In England there is a plethora of vocational and GCSE qualifications at Key Stage 4 and a bewildering variety at Key Stage 5 including ICT and Computing A levels, diplomas and BTEC (and equivalent) qualifications all of whose content varies according to different examination boards.
- New functional skills qualifications in mathematics, English and information and communications technology cover a range of skills including the ability to use various business packages, write letters and produce leaflets and spreadsheets. These are available as part of other qualifications such as diplomas and apprenticeships and also as 'stand alone' qualifications at different levels. They are popular with pupils and have tangible outcomes.
- There is a requirement for all schools to provide ICT across the curriculum (ICTAC). This intends that all pupils should be able to access all subjects using ICT but budget cuts will limit implementation.
- Scotland's new Curriculum for Excellence clearly designates ICT as a transferable skill to be used across the curriculum 'to enhance learning and teaching'. Computing is classified as technology not science along with DT.
- There is a lack of computing expertise among teachers in general.
- The Wolf Report of vocational education acknowledges the usefulness of an ICT/IT GCSE but notes there are also useful vocational qualifications.

Extra-curricular Approaches (Ian Nussey)

Changes to courses and syllabi alone are not sufficient to attract more young people to computer studies. Schemes run by engineers already offer extra-curricular enrichment activities to young people in primary and secondary schools. These include Young Engineers, Imagineering, GO4SET and Primary Engineer and enable school pupils to become familiar with engineering concepts and contexts. A similar initiative from computer scientists aimed at the most able school students could inspire young people about the exciting possibilities of computing by 'building things that actually work'. There is a vast range of technical possibilities but schools may lack the specialist expertise which enrichment schemes could provide to complement and strengthen the impact of formal courses.

Workshop: Supply and demand

This session considered the skills requirements of IT employers and computer science courses in higher education by starting with the results from a number of employer surveys that had been circulated prior to the meeting. The main focus was on the relevance of ICT and computing skills to each area of the economy and on the relationship between ICT and computing.

Discussion points:

- Could school-based education and training ever be enough? There is a spectrum of employment roles that require ICT and computing skills. At some levels, for example work in a call centre, general ICT knowledge may suffice. A mixture of ICT and computing skills may be needed in other roles. School qualifications are not relevant at a research level.
- Literacy, numeracy and ICT are just basic skills and are implicit in higher level skills but do not provide sufficient basis for progression to computer studies on their own. Key Stage 3 (KS3 – pupils aged 11-13 years) is a 'problem area' when young people lose interest in progressing to computer studies. Higher level skills such as programming could be 'pushed down' the school curriculum to engage much younger pupils at this stage.
- The principles of computation can be readily introduced in GCSE physics and mathematics as well as in GCSE computing.
- At present the focus in schools is on teaching software 'packages'. These rapidly change and become obsolete. People using packages don't need to understand how they work. Nothing about preparing a spreadsheet prepares you for being a computer scientist. Can we provide an underlying understanding of what's behind these tools that pupils can build on to progress? Can we identify higher level transferable skills for using packages which can be applied further?
- Employer surveys indicate they are generally satisfied with the IT skills of school leavers but 60 per cent are dissatisfied with their general skills. Many employers in the IT sector only require low level IT skills and often employ graduates with no computing skills. The skills IT employers value in order of importance are: security, business skills, technology specific skills, interpersonal skills, analytical and research skills.
- A level physics can be considered as less of a preparation for a physics degree and more an indication of aptitude in physics. What students really need for success in physics is mathematics. Computer studies at A level similarly needs to be a test of aptitude. Most computing courses in school are not about getting young people to progress to higher level computer studies. Would computing admissions tutors in higher education view any of the new computing A levels as valid qualifications for progression on a par with physics or mathematics?
- Computing is like engineering in its ability to manipulate and change things and can be widely present across different subjects. Abstract thinking skills are needed to develop as a computer scientist. Schools need help to distinguish between ICT and computing and the different skills they represent. New qualifications at A level (for example the AQA A level which is a different sort of A level) are helping with this.
- Young people don't seem to understand what computer scientists do. They understand that you need engineers to build computers but don't seem to understand that you need computer engineers to build cars and computers.
- Is the distinction between the two important or would it be possible to include computing in mathematics? Mathematics is a generic analytical skill underpinning both computing and engineering.
- There is currently a shortage of ICT and computing teachers so introducing a curriculum which can enthuse young people about computing presents a huge challenge. It is easier to change a university syllabus than a secondary school syllabus because the lead time need to train and put in place suitably qualified teachers is very long.

- Are bottom up movements in schools worrying about these issues? How can engineers and computer scientists get school heads to listen?

Workshop: are school courses fit for purpose?

This discussion considered the content of several of the most popular IT courses at KS4 (GCSE or equivalent) and KS5 (A level or equivalent) and whether they provide the skills employers and higher education needs.

Discussion points

- Why is there so much choice when 80 per cent of learners take fewer than 20 per cent of the qualifications on offer? Some schools may individually offer two or three different qualifications or even team up with an FE college to enable a wider offer to students. The Scottish IT working group for the new Curriculum for Excellence is moving towards a single qualification. The Wolf Review of vocational education suggests that teachers should retain choice of what qualifications to offer but that we should ensure those qualifications are worth teaching.
- Employers are confused by the qualifications offer. Surveys indicate they focus on what they know or recognise and ignore the rest. Employers generally see computing A levels are being of two different kinds: those which develop mainly generic ICT skills and those which test intellectual and analytical skills. Would a key to the knowledge and skills content of different qualifications be useful? The BCS could have a role in this.
- OCR Nationals have become very popular but there is no required core of modules so employers find it difficult to identify whether students have taken an ICT or a computing route through. Are there identifiable ‘tracks’ or ‘routes’ which ‘rising computer stars’ might take? Knowing what students know from different qualifications is an issue across all subjects. At entry level to higher education tutors are increasingly using aptitude tests as a way of determining whether young people have the required skills and abilities required to progress to computer studies.
- The A level syllabus itself is not the issue. It is self selection. Fewer students are applying to study computing at university because they don’t see it as a challenging, deep or an interesting area of study. Gender is a big issue.
- An exclusive focus on the purely academic or industrial relevance of ICT and computer studies may mean we undervalue the contribution of computing to our culture, every area of study and digital citizenship.

Plenary discussion.

Points from the workshop discussions were shared and used to develop a ‘gap analysis’ or summary of the extent to which the IT skills requirements of employers and higher education accord with the skills supplied by the range of IT qualifications available in schools and colleges. The main points raised were:

- ICT skills are increasingly relevant at all levels in school and industry. Employers and university admissions teachers understand ICT as general skills distinct and separate from analytical computing skills. More significantly they do not see ICT skills as providing a general basis for progressing to computing and computer science.
- The distinction between ICT and computing is not clear in schools, either across the curriculum in general or in the confusion of qualifications offered at KS4 and KS5.
- Young people do not understand what computer scientists do and do not see computing as interesting or inspiring.

- Employers are confused by the range and number of qualification on offer.
- Employers require both ICT and computer skills but in different combinations for different roles
- Admission tutors increasingly use aptitude tests to determine student skills for progression to computer studies.

This discussion in turn posed a number of questions for further consideration by the Computing in Schools study:

- How can we help young people to understand what computer scientists do?
- How can we inspire young people about computer studies?
- How can we help schools to understand the difference between ICT and computing? Can we make a clear distinction between them?
- Can we enable 'top down' advocacy to support the changes required to ensure schools supply the ICT and computing skills that industry and higher education need?
- How can we help employers to understand current qualifications and the skills and pathways embedded in them? Are there some qualifications or pathways with particular rigour and hence value?
- Can we simplify or streamline the present qualifications system?
- Graduate destination data from HESA conflates statistics for IT and Computing graduates. The employment prospects for each are likely to be different. Is disaggregated data available?
- The UK has a large fraction of the world's business in high-end computing (mobile telecom, scientific computing, entertainment CGI, computer gaming) where there are almost no large companies but a lot of graduate job opportunities. How does the study 'speak' to the plethora of small companies?
- Will the study consider school leavers who enter the industry without a university degree?

Participants:

Dr Philip Hargrave FREng (DCKTN) – chair
Dr Robert Sansom FREng (Cambridge Angels)
Dr Andrew Herbert FREng (Microsoft Research)
Prof. Jon Crowcroft FREng (Cambridge University)
Prof. Steve Furber FREng (Manchester University)
Nic Holt FREng (Fujitsu)
Dr Martin Thomas FREng
Prof Morris Slowman FREng (Imperial College)
Dr Peter Cochrane FREng (Concept Labs)
Prof Cliff Jones FREng (Newcastle University)
Dr Ian Nussey FREng (IBM)
Prof Alan Bundy FREng (Edinburgh University)
Prof Jeff Kramer FREng (Imperial College)
Dr Tony Field (Imperial College)
Prof Ian Leslie FREng (Cambridge University)
Colin Tregenza Dancer (Metaswitch)
Prof. David Milne FREng (Wolfson Microelectronics)
Prof. Matthew Harrison (Royal Academy of Engineering)
Anna Paczuska – rapporteur
Martin Smith (Royal Society)

Mandy Honeyman (Royal Society Advisory Group)
Libby Steele (Royal Society)
Bill Mitchell (British Computer Society)
Sue Nieland (e-skills)

Consultative event: teachers
Manchester, 18 March 2011

Introduction and background

This event was one of five stakeholder engagement events held in Spring 2011, in order to gather evidence for the Society's Computing in Schools study. The Royal Society is leading on this 18-month project looking at the way that computing is taught in schools, with support from 24 organisations from across the computing community including learned societies, professional bodies, universities, and industry. School teachers, academics and other members of the computing community are coming together through the study to address growing concerns that the design and delivery of the ICT and computing curricula in schools is putting young people off studying the subject further.

There were around 18 attendees at the Manchester event. Most were teachers, or heads of ICT/Computing within schools and colleges. Also in attendance were representatives from exam boards (AQA, WJEC and OCR) and organisations including the D & T Association and IEEE (Institute of Electrical and Electronics Engineers).

Group 1 discussion: Curriculum

There was a broad ranging discussion which is captured well in the plenary feedback. There was general agreement that computing should be a discrete subject at least at KS4, though plenty of examples of how it was being used to bolster ICT (and the GCSE in Computing was one of these). Lots of teacher issues raised. View expressed that you need to fix ICT curriculum first before you tackle computing.

Group 2 discussion: Staffing

Training and recruitment

There was general agreement within the group that the quality of some newly-qualified ICT teachers is not of an acceptable standard, with some individuals not having a basic understanding of their subject. It was noted that there are more applicants for teacher-training in a recession, and that a small number of these are there for the wrong reasons i.e. they don't particularly want to teach, but there are a lack of alternative options.

There is a lot of variation of first degree subjects studied by those undertaking ICT/Computing teacher training, with massive differences in the amount of computing they have done. People may have part of a degree in business, computing etc. As backgrounds are so varied (one may have expertise in programming, another in designing websites etc) peer teaching is often utilised in order to share expertise.

Some universities have closed their ICT/computing teaching departments, others are experiencing declining numbers. This is partly due to a move towards more school-based, rather than university-based, training.

Computing at HE

There is a severe gender divide an undergraduate level, with one attendee citing a course of 60 computer science graduates containing no women.

Why has computing lost ground, with declining take-up at HE level? Maybe as the novelty of subject has worn off. In 1980s and 1990s computing was viewed as new and exciting. Nowadays however, computing is not viewed by everyone as a prestige specialist subject in same way as e.g. physics is, but as something ordinary and that everyone can do to some extent (conflation between ICT and computing).

Teaching and the curriculum

The KS3 curriculum is especially monotonous and boring. The National Strategy guidelines are overly adhered to, particularly by non-specialist teachers. Sometimes teachers do complain but school line is "teach the Strategy". At KS3 bright students can be turned off by data entry type exercises where they have to fill in databases, but do not learn the potentially exciting uses to which a database can be put.

At GCSE, the high percentage of coursework (60% of the qualification) can make lessons relentlessly boring. The group discussed whether coursework should and could be improved to make it less boring, or whether decreasing the coursework element was the best option.

Curriculum design

Ideally business and industry should be involved in creating qualifications, but this can be very difficult to achieve in practice. The recent attempt with Diplomas in the UK was highlighted. Are vocational qualifications any better? Not necessarily - BTEC specification mentioned as being low quality.

CPD

This project should not just focus on ITT, but also on ensuring existing non-specialist teachers are given better training. A major hindrance to increasing CPD for teachers is the rarely cover policy, which makes it extremely difficult for teachers to get the time to participate in CPD. A newly qualified teacher is not the finished product, and especially not in computing, as it is such a fast-moving subject, and so may require more CPD than other subjects

Some motivated teachers will seek CPD opportunities, but the cost can be prohibitive, for instance to study for a modules of an MSc. This may be as these courses are seen as industry-relevant, and therefore as something businesses may pay for their employees to attend. Group wondered whether BCS does anything for computing, in the way that the Royal Statistical Society does for mathematics.

Further Education

It was noted than in FE many teachers do have industry experience. Also that some graduates are working a few years in industry before moving into teaching, partly to make money to clear student debts.

<u>Plenary discussion</u>

Teachers

Good specialist teachers will teach elements of computing such as programming in KS3 e.g. by using Scratch, and then making sure students are aware that what they have been doing in the lesson is computing, as opposed to ICT. This is especially important for higher ability students who may go on to pursue computing in the future.

Some teachers thought that ICT / computing teachers not having a computing background was not a problem, and that providing they are interested in the subject, and willing to learn, they can teach it successfully. Additionally, it is impossible to ignore the fact that most teachers will come from an ICT background rather than a computing one, as there is not a computing PGCE.

New teachers of all subjects who have grown up with ICT will automatically think in terms of using ICT to support their subject when needed. If this is the case, do we need specific ICT lessons at all? One attendee's role (Michael Reid) is to embed ICT in all subjects across the school curriculum.

Some participants noted that the teachers attending today's event are not representative. Many schools represented are selective or private, plus only teachers who are interested or concerned enough about the issues will have chosen to attend. Not all schools will have the staff required to deliver fully successful ICT and computing lessons, or have the luxury of being able to send staff on a CPD programme that may mean one day out of school for six weeks.

Curriculum

There is a need for flexibility in the computing curriculum so students can focus on the areas that most interest them, be it programming or something more people-focused.

ICT will inevitably overlap with other subjects that use ICT in some way – it is an inherently interdisciplinary subject. Forcing this into pigeon-holes to create discrete ICT lessons is not a good teaching method, and likely to lead to some boring or unimaginative lessons.

The overlap between computing and ICT is inevitable and not necessarily a problem, in the same way there will be some overlap between English literature and English language.

To eliminate the problems with computing in schools it may be that the first essential step is to fix the problems surrounding ICT (not vice versa as we are trying to do...)

One possible solution might be to get rid of ICT at GCSE, by teaching all the ICT needed at primary and KS3.

Employers are looking for "T-shaped individuals" who have breadth of knowledge and skills (i.e. generic ICT skills such as using MS Word and Powerpoint), but who also have depth of knowledge in some specific areas. The issue lies in determining in which areas depth of knowledge is required.

Senior management and student views

Senior management in some schools do see ICT as a tool that supports learning in other subjects, rather than as a subject in its own right. Some head teachers see no need to provide computing at A-level as universities do not require it for entry. Also, anecdotally, students think it is more difficult to achieve an A at A-level in computing, as compared to some other subjects.

Higher education

At universities there is a split between HEIs teaching old-style programming focused computer science qualifications, and newer HEIs e.g. Teesside, who are teaching more innovative courses.

General

So what to do? Need to get rid of misconceptions, and to have good case studies of people succeeding in computing. Need to counteract media stories which only highlight computing when something goes wrong e.g. government databases.

Getting computing accepted as part of STEM would be a positive first step.

Computing in Schools – consultative event: Higher Education

Thursday 24 March 2011, Queens Hotel, Leeds, LS1 1PJ

Summary

This report summarises the discussions of a consultation on the way that computing is taught in schools held in Leeds on Thursday 24 March 2011. Part of the Royal Society's on-going 18-month project launched in August 2010, the aim of this event was to get a deeper understanding of the issues relating to computing in schools and how these are viewed from the perspective of higher education. An introductory session to the meeting presented the background to the Royal Society study and findings from its initial call for evidence from interested parties. Three discussions focused on exploring the major themes and issues emerging from the evidence, the outcomes of which were presented and discussed further in subsequent plenaries. The first of these considered the computing A-level as a potential prerequisite for a computing degree. The second sought the views of HE academics on what their ideal A-level or equivalent qualification would look like. A final discussion considered how schools and HE can collaborate to raise the profile of computing and encourage uptake of the subject at university level.

Introduction – Roger Boyle (University of Leeds)

Roger Boyle introduced the background to the Royal Society project. From 2006-10 the number of students studying ICT GCSE has dropped by 44% from around 115,000 to around 65,000. Over the past seven years take-up of A-level computing has suffered a 60% decline with numbers falling from just over 10,000 in 2003 to around 4,000 in 2010. Over the same period as these negative trends in schools universities have experienced a drop in applicants, though in recent years this decline has stopped and a fragile recovery has followed. These statistics and growing concerns within the computing community led the Royal Society to launch this study into the teaching of computing in schools. An initial call for evidence in late-2010 attracted over 120 responses from individual teachers, students and parents alongside corporate responses from employers, universities and learned societies. Approximately half the institutions represented by delegates at this meeting had contributed to the evidence. The responses received highlight seven main issues of concern:

- the supply, retention and numbers of specialist teachers in schools and colleges;
- a lack of quality subject-specific CPD for ICT/computing teachers;
- factors affecting the failure of the ICT curriculum to engage students;
- confusion caused among students by the use of overlapping terminology 'ICT' and 'computing';
- the influence league tables statistics have on a school's decision to offer or to enter students for computing qualifications;
- a lack of understanding of ICT/computing by senior management in schools and colleges; and
- students' negative perceptions of computing as boring, geeky or difficult.

In addition to this event, the Royal Society has organised additional stakeholder events to seek the views of teachers in schools and head teachers, professional bodies and other organisations. (Reports on these meetings are published separately.) The Royal Society has also commissioned additional research to collect more data on who is teaching computing in schools and colleges, the supply of specialist teachers and the current types of CPD available to ICT/computing teachers.

Note: aware that the terms 'computing', 'ICT' and 'IT' are not well defined and are used interchangeably in different communities, the Royal Society defines the terms in the following way to clarify discussions in this study:

- **Computing**: the scientific discipline of computing, covering principles such as algorithms, programming, design, problem solving *etc*.
- **ICT**: the technology and application of computers, including the skills of using computer applications, systems management and computer networks.

This closely reflects the terminology widely used in schools.

Discussion 1: Computing A-levels

For this session delegates were asked to consider what would have to happen for A-level computing to be a prerequisite for a computing degree. Discussions focused on the need for a review of the A-level computing curriculum, identified potential benefits of a prerequisite on computer science degrees and the barriers to introducing this requirement. Through the discussion it became apparent that HE computer science departments are positive about the recent increase in students taking A-level maths in schools and, as a result, the suggestion of a full A-level in 'Maths for Computer Science' was not favoured because it might affect this trend in A-level maths uptake.

For computing A-level to be a prerequisite for a computing degree a clear separation between ICT and computing as disciplines is required to emphasis computing/computer science as a credible academic discipline like physics and maths. Re-branding the A-level as computer science, rather than computing, might also change the perception of the subject's academic qualities.

A review of the A-level computing curriculum would be needed. Components that this curriculum should cover include: computational thinking, programming and skills such as problem-solving, analytical thinking, evaluating, modelling and design. Creativity and innovation are also crucial to show the diversity of the subject. Intellectual rigour must be built into the curriculum content while the way it is delivered and assessed should not discourage students from failure, which plays an important role in the development of knowledge. The prerequisite curriculum should also include content that shows the diversity of the subject through the history of computing and its impact on society. These components could also act as a useful marketing tool for computing and encourage students to progress with their studies in HE.

Several potential benefits of an A-level computing prerequisite for computer science degrees were identified:

1. an improved awareness among incoming students of what they will meet in a computer science degree. This could reduce the high attrition rates for computer science in HE[1];
2. the removal of remedial work in the first year of study. This would reduce the burden curve students experience in the first year and allow them to move further and faster in computing degree courses;
3. HE departments could agree and develop a template for first- and second- year components of computer science degrees to be used across the UK; and
4. higher quality graduates with better employability skills.

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[1] It was noted that work by Mantz Yorke for the Higher Education Academy on the student experience was relevant reference material here (available from http://www.heacademy.ac.uk/assets/York/documents/resources/publications/FYEFinalReport.pdf)

However, the current low numbers of young people studying computing makes the prerequisite option unattractive. This option is only viable with greater numbers studying A-level computing. Without more students studying A-level computing before the prerequisite requirement is introduced HE computer science provision across the UK could shrink because of a lack of applicants to courses. How would this gap between requirement of prerequisite and growth in student uptake in A-level computing be bridged? A review of the issues related to the maths/further maths requirement for maths degrees might offer a solution. The perception of computing among parents and wider society must also be addressed if more students are to be encouraged to study the subject post-16.

A barrier that would need to be overcome for an A-level prerequisite to come about is the diversity in the computer science sector in HE. HE computer science departments have developed courses that cater for students with or without computing A-level. This was expected to remain the status quo, allowing departments maximise their student intake. Currently, some UK HE departments insist on students having A-level maths for entry onto computer science degree programmes, others do not. This diversity will make it difficult for the HE computer science community to develop a common approach to a prerequisite – for the requirement to be an effective means of increasing the numbers studying computing at A-level all departments would have to subscribe to policy.

The lack of uniformity across awarding bodies' different A-level specifications, and the range of post-16 qualifications (BTecs, IT Diploma *etc*), are also barriers to the introduction of a prerequisite.

The introduction of a prerequisite posed several questions for further consideration:

- Will insisting on a computing A-level help the gender issue in computing? The publications *Unlocking the clubhouse: women in computing* by Jane Margolis (published by MIT) and *Records of women into computing*, a study by Barbara Segal (UCL) offer useful information on the gender issue.
- What impact would an A-level prerequisite have on departments' intake of capable students who have no access to post-16 computing qualifications in their schools or colleges? Students' views of computer science and why they are not taking up computing post-16 should also be sought.

The discussion prompted several questions about the current effect of computing A-levels on computer science in HE that need to be explored further:

- Are the A-levels in ICT and computing damaging to uptake of computer science in HE?
- Is A-level computing too challenging? Does the mathematical content deter some students?
- Does the ICT A-level distort students' expectations of computing degrees?
- Does the ICT A-level connect with the computer science degree? Students might hold the misconception that ICT A-level is an appropriate route to progression onto a computer science degree.
- Is the ICT A-level pulling some capable students away from post-16 computing options? Perhaps ICT should be re-branded to avoid any confusion with a computing qualification which prepares students for studying computer science in HE? Over time, this change might drive up numbers studying A-level computing.

A recommendation could be that information, advice and guidance (IAG) available in schools, and through careers advisers, should emphasise that ICT A-level is not an appropriate pathway to progression to a computer science course in HE.

Delegates acknowledged that developments at A-level may not affect student uptake of computer science post-16 because some are already turned off computing by KS4. More work needs to be done to engage students in computing in early years (Key Stages 2 and 3).

Finally, although computer science is central to science, technology, engineering and mathematics (STEM), the discipline is often overlooked in current STEM initiatives. This is a significant problem for the subject. Could organisations including the Royal Society, BCS and e-Skills promote the profile of computer science as a scientific discipline and as the common core of STEM?

Discussion 2: Ideal A-level or equivalent qualifications

This discussion considered the knowledge and skills HE would ideally want a new entrant to a computer science degree to arrive with. Currently, students coming into computing degrees have a varied set of skills. This situation is different compared with the traditional sciences such as chemistry, for which a subject-specific A-level prerequisite has helped to standardise the skills of the student intake to some extent.

In an ideal world, the post-16 computing courses should cover three areas: programming, computational thinking and computer systems/architecture[2]. The curriculum content would be delivered in a way that enthuses, excites and challenges students. Ideally, entrants to an undergraduate computer science course would:

- possess a good suite of transferable skills, such as independent study and research skills, and interpersonal skills;
- be able to communicate technical information to a non-technical audience;
- have an engineering attitude;
- arrive with a sense of excitement about the subject, which tends to develop through hobbyist activities;
- be familiar with computational thinking.
- a broad brush understanding of logic and programming. (Is there enough programming-related continuing professional development (CPD) support available to teachers to develop their confidence in teaching this component of computing? Is the A-level assessment model fit-for-purpose?);
- an understanding of how computer scientists work with computers – content related to critical thinking, algorithms, abstraction, data structures;
- have covered computer systems and architecture to develop an understanding of computers as memory machines;
- an understanding of the historical context of computing and the breadth of its applications in the real world.

It was recognised that all this would be difficult to achieve in a two-year A-level course. So some of these computing principles would need to be introduced before post-16 study.

Other points raised as part of this discussion cover the need to communicate to students what a degree in computer science entails and offers to them before they decide on post-16 courses. The HE computer science community needs to convey a clear message to schools about what contribution/benefits computer science makes to the overall education of children in school. If computing is worth including in the school curriculum,

[2] It was commented that work by Brian Cantwell-Smith on 'Foundations of Computing' was relevant in considering the underlying concepts of computing (available from http://www.ageofsignificance.org/people/bcsmith/print/smith-foundtns.pdf)

it must benefit all children, not just those interested in pursuing the subject post-16 and in HE. HE could offer a lot of useful input on what knowledge and skills in computing students need to develop at appropriate ages in the curriculum.

Discussion 3: School/HE collaboration

This discussion considered the ways in which HE and schools could collaborate through outreach initiative to raise the profile of computer science and encourage the uptake of computing in HE. The session revealed that there is demand from schools for outreach activities in computing and a lot of successful outreach is happening. The CAS initiative and BCS programmes are good examples of work to inspire students and promote enthusiasm for the subject. Technocamps is an example of an outreach initiative aimed at 11-19-year olds in Wales. The main points raised were:

- Computer science should learn from those communities, such as maths, that run successful outreach programmes. For example, can computer science replicate the maths scheme where HE teachers deliver first-year degree components as 'taster sessions' in schools?
- HE academics need to enthuse their colleagues in the department about taking part in outreach activities. Could HE departments encourage their staff to get involved in enthusiast groups run as after-school clubs?
- Competitions, such as the Informatics Olympiad, are more popular in Europe than in the UK. HE could provide support to help schools take part in these competitions. Can corporate-sponsored competitions help to attract more girls to computing in school?
- HE departments could adopt a creative approach to research so that schools and their students can get involved.
- It can be difficult to identify the outreach coordinators in schools and maintain these relationships. A recommendation might be for BCS and CAS to consolidate their data into one easily accessible shared national contact database for schools/HE outreach. A database and centralised resource of existing CPD resources for HE academics to take to and use in schools would also be welcomed.
- CPD for teachers is an area where HE can offer valuable input and advice. The Computers in Schools Project has done much work to introduce news ways of teaching the new GCSE in computing. HE needs to do more to influence and support teachers in delivering the ICT/computing curriculum in schools. HE could do a lot to support CPD initiatives for school teachers, such as the VITAL programme. Teachers want their CPD to focus on theoretical aspects of computer science because many teachers lack confidence to teach elements of the subject. Computer science departments should link up with HE education departments offering CPD to provide the subject knowledge content teachers want from these courses. Should CPD events be run in schools on INSET days, rather than at HE departments? These events could not only be aimed at ICT/computing teachers but also designed to show science and maths teachers how computing could be useful in the teaching of these subjects.
- Is it possible for HE departments to promote computer science undergraduate and graduate case studies in schools? Are messages relating to successful role models (men and women) getting out to young people? The varied roles of computer scientists needs to be emphasised. Could HE link up with organisations, such as BCS, to run a competition to identify a 'star' communicator for computer science?
- Can the computer science community encourage other subject bodies (physics, engineering and maths) to show how important computer science skills are to their disciplines?
- HE computing degree programmes should include an educational/outreach module in the final year. Computing departments should be in contact with the ICT/IT coordinator in their local PGCE provider so that computing students interested in teaching are fed through for PGCE training. This would

help to increase the number of specialist computing teachers in schools.
- In future HEIs will have to invest a proportion of their income from tuition fees in outreach/widening participation activities. The Royal Society report will provide evidence for computer science departments to justify activities as valid outreach toward this requirement.

Computer science students can and will play an important role in the future digital economy of the UK. A recent NESTA report highlights a real financial issue for the UK economy if HE cannot supply the high-skilled computer science graduates. This provides a clear incentive for a shake up of computing in schools and a focus for HE to engage with students in schools to attract them to study computing in HE. A recommendation is that the Royal Society review and consider the recommendations in the NESTA report on the UK supply of e-skills, *Next Gen. Transforming the UK into the world's leading talent hub for the video games and visual effects industries,* published in March.
(http://www.nesta.org.uk/areas_of_work/creative_economy/skills_review/assets/features/next_gen)

Participants:

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Jeremy Bradley (Imperial College London)
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Computing in Schools – consultative event: head teachers, professional bodies and other organisations

Monday 28 March, Royal Society, 6-9 Carlton House Terrace, London SW1Y5AG

Summary

This report summarises the discussions of a consultation on the way that computing is taught in schools held at the Royal Society on Thursday 28 March 2011. Part of the Royal Society's on-going 18-month project launched in August 2010, the aim of this event was to get a deeper understanding of the issues relating to computing in schools. An introductory session to the meeting presented the background to the Royal Society study and findings from its initial call for evidence from interested parties. Four discussions focused on exploring the major themes and issues emerging from the evidence, the outcomes of which were presented and discussed further in subsequent plenaries. The first two discussions looked at the place of computing in the school curriculum and the resources, staff and training available to support the teaching of computing in schools. The third focused on how computing should be structured and delivered in schools. A final discussion sought views on what needs to be done to improve the uptake of computing in schools and HE.

Introduction – Simon Peyton-Jones (Microsoft Research Limited)

Simon Peyton-Jones introduced the background to the Royal Society project. From 2006-10 the number of students studying ICT GCSE has dropped by 44% from around 115,000 to around 65,000. Over the past seven years take-up of A-level computing has suffered a 60% decline with numbers falling from just over 10,000 in 2003 to around 4,000 in 2010. These statistics and growing concerns within the computing community over the teaching of ICT/computing in schools and its affect on young people's enthusiasm for computing led the Royal Society to launch this study into the teaching of computing in schools. An initial call for evidence in late-2010 attracted over 120 responses from individual teachers, students and parents alongside corporate responses from employers, universities and learned societies. These responses highlight seven main issues of concern:

- the supply, retention and numbers of specialist teachers in schools and colleges;
- a lack of quality subject-specific CPD for ICT/computing teachers;
- factors affecting the failure of the ICT curriculum to engage students;
- confusion caused among students by the use of overlapping terminology 'ICT' and 'computing';
- the influence league tables statistics have on schools' decisions to offer or to enter students for computing qualifications;
- a perceived lack of understanding of ICT/computing by senior management in schools and colleges; and
- students' negative perceptions of computing as boring, geeky or difficult.

Alongside this event, the Royal Society has organised three events to seek the views of teachers of ICT/Computing, and one event to seek the views of computer scientists working in higher education. (Reports on these meetings are published separately.) The Royal Society has also commissioned additional research to collect more data on who is teaching computing in schools and colleges, the supply of specialist teachers and the current types of CPD available to ICT/computing teachers.

When asked by the chair what particular issues had driven delegates to attend the event responses included:

5. concern over the lack of depth in the computing curricula and dissatisfaction with ICT studied by children;
6. getting more students to study computer science in HE to meet demand from employers for high-quality computing graduates;
7. poor quality ICT delivery in schools;
8. the gender issue – getting more girls to study computing in schools; and
9. a desire to see the teaching of computing reinvigorated.

Note: aware that the terms 'computing', 'ICT' and 'IT' are not well defined and are used interchangeably in different communities, the Royal Society defines the terms in the following way to clarify discussions in this study:

- **Computing**: the scientific discipline of computing, covering principles such as algorithms, programming, design, problem solving *etc*.
- **ICT**: the technology and application of computers, including the skills of using computer applications, systems management and computer networks.

Discussion 1: Curriculum issues

This session sought delegates' views on the teaching of ICT and computing in schools and how the subjects should fit into the school curriculum. High-stakes assessment at Key Stage 4 and the associated league table statistics were identified as having a negative effect on students' learning experience of ICT/computing during Years 10 and 11.

Delegates viewed computing as a discipline in its own right. Computing concepts, including elementary programming, should be taught to all students at Key Stage 3, and even earlier. Elementary programming should be introduced at Key Stages 1 and 2 for all to expose young people to the core concepts of computing as early as possible. The specific core principles should be determined through a consultation run by the Royal Society, but these fundamental concepts might include: problem-solving; programming and abstraction; algorithms and data structures (already done at KS1); and analytical skills. These concepts should be delivered in a way that encourages collaborative/group work, which leads students to use their creative skills. Recent feedback from heads of Scottish HE computer science departments suggests children aged 5 and up can start to develop theses skills through activities based on exploring data structures such as Venn diagrams, timetables, knitting patterns *etc*. However, availability of teachers with the required subject background and confidence could limit the teaching programming.

ICT/digital literacy needs to remain in the school curriculum. Although feedback from A-level students suggests that ICT at GCSE is boring, there is scope for using ICT as a vehicle for computing in early years teaching and then computing to be a discrete subject later on at Key Stages 4 and 5.

With no assessment in Key Stages 1-3, teachers can innovate in the ways they deliver the ICT curriculum. There are examples of how to offer high-quality integrated project work to stretch and challenge high-attaining students (level 8) at year 9. However, high-stakes assessment of GCSEs and unforeseen negative effect of league tables have driven the teaching of ICT/computing at Key Stage 4 to a repetitive, reductive approach. Perceived problems with the ICT/computing curriculum at Key Stage 4 are:

- the curriculum is too broad. This encourages non-specialist teachers to cherry-pick the topics and

skills they cover to fit with their subject knowledge;
- the curriculum criteria and assessment lack clarity, in particular level descriptors of achievement are too vague. The curricula for maths and the sciences have more clearly defined learning goals/achievement targets;
- the lack of subject-specific expertise among ICT/computing teachers and the influence of league table performance puts teachers off developing programmes of study that challenge their more capable students;
- the culture of league tables in England also inhibits awarding bodies from developing challenging courses.

Does the QCDA study on raising the bar in ICT at KS4 offer recommendations to address these issues?

If computing cannot be delivered to all as a discrete subject at Key Stage 4, for example because of a lack of specialist teachers, could computing be delivered through the curricula physics, D&T, maths *etc*? This would broaden the audience of computing and increase the pool of potential A-level students. Some delegates believed that the only case for a cross-curricula approach is in the Key Stages 1-3, and only when the skills to be delivered through the other subject curricula are clearly defined and assessed. The limited subject-specific knowledge of non-computer science teachers is likely to limit the success of a cross-curricula approach at Key Stage 4.

The status of ICT in the National Curriculum must be improved. ICT is often seen as a filler subject on the timetable by senior management in schools. This can lead to ICT lessons being taught by non-specialist teachers who are not enthused or interested in promoting the subject. If more young people are to enjoy the subject and be encouraged to continue to study computing post-16, a good supply of specialist teachers is vital. To attract these specialists computing must be recognised as a discipline that is worth teaching.

Other comments prompted by the discussion include:

- A disruptive, subversive attitude to technology drives innovation yet there is no mention of hardware or the physical basis of computing (computing systems) in the current curricula. Do students need an understanding of what is happening inside the 'black box'?
- The separation of ICT and D&T in schools is detrimental to both subjects. Robotics is a good example of the application of both subjects together and provides an excellent context for project work. A culture of teaching subjects in 'silos' should be avoided.
- The provision of challenging project work on object-orientated programming at A-level is limited by the assessment model and moderators' interpretation and understanding of such projects.
- Any new curriculum or qualifications for computing needs to be supported by accessible information, advice and guidance (IAG) for school management, teachers, parents and students.

Discussion 2: Resourcing, staffing and training issues in delivering computing

This discussion focused on the provision of continuing professional development (CPD) for teachers and identified issues relating to IT infrastructure in schools that limit the learning experiences teachers can offer their students.

Teachers welcome opportunities for CPD. However, to simplify CPD provision and minimise costs, the current trend is for schools to schedule teachers' entitlement to five days of CPD to regular INSET days for all teachers. Should teachers be able to choose how they spend their five days of CPD? This is increasing difficult for schools to offer since the introduction of the 'rarely cover' policy and cuts to school budgets. So does the supply of CPD now have to be school-based? Are there other mechanisms, such as social networking, through which subject-specific CPD can be delivered? Can bite-size CPD resources be developed, with input from industry, that teachers could access remotely through their computers? After-school activities, designed with teachers' CPD in mind, might also have a role to play here.

When developing CPD programmes the ICT/computing community and teacher trainers should consider the knowledge, skills and understanding teachers require. Teachers need a blended experience that provides subject knowledge and an understanding of how to teach this knowledge effectively to students in their own school environments.

Importantly, there is no incentive for teachers to do CPD, in whatever form. In other countries, *eg* Spain, teachers must meet CPD requirements to progress their careers and salaries.

In discussing the IT infrastructure in schools the delegates identified the knowledge base among IT support staff in schools as an issue. Network managers and IT support staff can work in isolation and they lack the kind of a support network teachers benefit from, though regional support networks are developing across the country.

The relationship between ICT/computing teachers and network managers and IT support staff is an important factor in determining the quality of teaching that can be delivered in the classroom. Where there is a separation between the two groups teachers can meet barriers to developing the learning environments they want to support their teaching. This can be a particular problem in schools where the IT network and systems support is supplied by a remote provider. ICT/computing staff must be involved in the school's procurement process for such remote providers.

A solution to sourcing required software is cloud computing, in which programs and data are available on-demand via the internet. This is likely to be the way forward for IT infrastructure in schools.

Discussion 3: In a utopian world...

Delegates were asked to offer their visions of how, in a utopian world, computing should be structured and delivered in schools. One vision of computing in schools would see ICT redefined within the National Curriculum and comprising three elements: computer science (ICT as the creator); digital literacy/capability (ICT as the user); high-end user skills (societal/ethical issues associated with using ICT). Since there is no requirement for assessment at Key Stages 1-3 these early years offer the greatest opportunity to create and build young people's interest and enthusiasm. Therefore the underlying principles of computing would be included in these early stages of teaching. These principles should be taught with an emphasis on creativity and challenge in computing. The current e-safety agenda constrains creative teaching in the classroom. This would be reviewed to allow teachers to develop learning experiences that use the wide variety of materials available. The curriculum would be delivered in a learning environment which encourages a risk-taking culture among students. Failure should not be discouraged among students because it is integral to learning. Teachers would, however, need to support students in finding correct solutions. A fit-for-purpose assessment model must support this vision.

Another vision put forward would aim to inspire students in computing through a narrower curriculum delivered through higher quality participation for students. The curriculum would promote an open-starting point approach to teaching, which empowers young people to design their own learning experience.

Other views on how computing should be structured and delivered in schools included:

- computer science included as a science in the English Baccalaureate;
- more involvement from industry, HE academics and experts in the development of the curriculum, particularly at A-level to ensure that concepts are embedded in interesting and real-world contexts.

Constraints to developing and implementing any ideal computing learning environment in schools include:

- the cost of CPD for teachers so that the intended changes are implemented effectively in the classroom;
- support from industry for a new qualification is vital to encourage awarding bodies to consider developing it.

Discussion 4: Promoting the study of computing

In the final session delegates shared their views on what needs to happen in order for computing to be studied more widely, and for more pupils to go on to higher level study of computing in the UK. Suggestions for what needs to be done were varied but there was broad agreement that students' experiences of computing should be enhanced through a range of activities before they decide on their post-16 options.

Opinions were split among delegates as to whether ICT, *ie* the core principles and skills we want to deliver outside of discrete computer science, would need to be re-branded. Similarly, a call for ICT to become a part of the school measurement system received a mixed response. Would this require inspection by Ofsted, which previously has not always been helpful to ICT?

Teaching of computing in the early stages of secondary school would need to make students 'digitally savvie' at end of KS3 so that they can make informed decisions on computing option at GCSE.

The A-level computing qualification would need to be recognised as an entry qualification to computer science degrees in HE. How can HE computer science departments be influenced to make this proposal mandated across all of HE? A potential route to getting HE buy-in would be to give universities the opportunity to help redesign the new computing curriculum. Post-16 study in computing might allow students to start computer science degrees from different starting points or pursue other options in the first year of study in HE. Could university computer science departments be encouraged to design their courses so that such differentiation in the first year is possible?

The suggestion of a prerequisite qualification for entry to university computer science courses also raised concerns among some delegates. The requirement for a post-16 computing qualification must not put off those students that already go on to computer science degrees with no formal computing qualifications at GCSE/A-level. As an alternative to a prerequisite, could the computing community influence HE to recognise the value of post-16 computing as a supporting subject in UCAS applications, in a similar way to A-level maths and further maths?

Could computer science undergraduates be encouraged to become ambassadors for the subject? By spending time in schools these students can help to engage and inspire students to study computer science in HE. To broaden the appeal of such a scheme beyond those undergraduates interested in teaching, it is recommended that HE departments market the scheme as developing broader employability skills, which industry value and students often overlook. TeachFirst is in the early stages of working with computer science departments in HE on a programme, designed to take undergraduates into schools to support teachers and find out more about teaching as a career. The University of Westminster also runs a similar course. Could the industry year of four-year computer science degrees include a six-week teaching component? The existing Undergraduate Ambassadors Scheme credits students for working in schools during their degrees.

What can be done to encourage more provision of extra curricular activities, such as Technocamps, Computer club for girls *etc*? A directory of these types of activities needs to be collated and disseminated to teachers.

It is fast becoming the norm that the technology students have access to at home is better than that offered in schools. Is there an opportunity to use this access to ICT technologies at home to develop young people's interest in computing? Appropriate resources to support this need to be identified. This approach may open up time in the classroom to deliver more 'powered down' activities focused on developing the core skills of computing, *eg* problem-solving, analytical and thinking skills. Can the ICT/computing community call for provision of new technologies, such as tablets for students, browser interfaces, in schools for all?

A reason for the low numbers doing computing A-levels and computer science courses in HE is because talented students that can do the course are choosing to study other subjects. Young people must be made aware of the potential career opportunities open to someone with computer science skills in a future UK economy where IT-based innovations and industries will drive growth.

Participants:

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Bill Mitchell (BCS Academy of Computing)
Simon Peyton-Jones (Microsoft Research Limited)
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Computing in Schools – consultative event: teachers

Thursday 31 March, Royal Society, 6-9 Carlton House Terrace, London SW1Y5AG

Summary

This report summarises the discussions of a consultation on the way that computing is taught in schools held at the Royal Society on Thursday 31 March 2011. Part of the Royal Society's on-going 18-month project launched in August 2010, the event was one of three meetings of invited teachers held across the country (two similar teacher meetings were held in Manchester and Glasgow on 18 and 22 March 2011 respectively). The aim of these events was to get a deeper understanding of how issues relating to computing in schools are viewed from the perspective of the teacher in the classroom. An introductory session to the meeting presented the background to the Royal Society study and findings from its initial call for evidence from interested parties. Three discussions focused on exploring the major themes and issues emerging from the evidence, the outcomes of which were presented and discussed further in subsequent plenaries. The first discussion considered ICT and computing as subjects in the school curriculum. The second sought teachers' views on the available resources, staff and training to support the teaching of computing in schools. A final discussion looked at how the ICT/computing community could raise the profile of the subject with school management, pupils and parents.

Introduction – Graham Macleod (Little Heath School)

Graham Macleod introduced the background to the Royal Society project. From 2006-10 the number of students studying ICT GCSE has dropped by 44% from around 115,000 to around 65,000. Over the past seven years take-up of A-level computing has suffered a 60% decline with numbers falling from just over 10,000 in 2003 to around 4,000 in 2010. These statistics and growing concerns within the computing community over the teaching of ICT/computing in schools and its affect on young people’s enthusiasm for computing led the Royal Society to launch this study into the teaching of computing in schools. An initial call for evidence in late-2010 attracted over 120 responses from individual teachers, students and parents alongside corporate responses from employers, universities and learned societies. These responses highlight seven main issues of concern:

- the supply, retention and numbers of specialist teachers in schools and colleges;
- a lack of quality subject-specific CPD for ICT/computing teachers;
- factors affecting the failure of the ICT curriculum to engage students;
- confusion caused among students by the use of overlapping terminology 'ICT' and 'computing';
- the influence league tables statistics have on schools' decisions to offer or to enter students for computing qualifications;
- a perceived lack of understanding of ICT/computing by senior management in schools and colleges; and
- students' negative perceptions of computing as boring, geeky or difficult.

Alongside this and the other teacher-focused events, the Royal Society has organised two additional stakeholder events to seek the views of computer scientists in higher education and head teachers, professional bodies and other organisations. (Reports on these meetings are published separately.) The Royal Society has also commissioned additional research to collect more data on who is teaching computing in schools and colleges, the supply of specialist teachers and the current types of CPD available to ICT/computing teachers.

When asked by the chair what particular issues had driven delegates to attend the event responses included:

- ensuring ICT or computing remains a discrete subject;
- the desire for more computing to be taught in Key Stages 3 and 4;
- the need for a review of ICT curriculum content with a view to including more 'real ' subject content;
- a concern that ICT/computing may be overlooked in National Curriculum review and not considered as important as other subjects in the review;
- the retention of IT specialist teachers in schools; and
- a frustration with the lack of credibility of ICT/computing within HE, which is a drawback when trying to promote the subject to students and senior management.

Note: aware that the terms 'computing', 'ICT' and 'IT' are not well defined and are used interchangeably in different communities, the Royal Society defines the terms in the following way to clarify discussions in this study:

- **Computing**: the scientific discipline of computing, covering principles such as algorithms, programming, design, problem solving etc.
- **ICT**: the technology and application of computers, including the skills of using computer applications, systems management and computer networks.

Discussion 1: ICT/computing as subjects and curriculum issues

This session sought teachers' views on the current state of the ICT and computing curricula in schools, how these are being delivered and whether the skills and knowledge they offer are appropriate for and useful to young people in 21st century society.

The discussion identified the transition from primary to secondary education as an area that needs to be addressed. ICT teaching at primary level is mostly skills based, though computing principles are present and it is these elements that provide interest for students. There is evidence of some excellent and engaging teaching at primary level. However, the 'ICT literacy' skills that today's students arrive with at secondary school vary greatly from student to student. Some Year 6/7 students lack problem-solving skills and are unaware of multiple ways of using interfacing with programs (*eg* using short-cut keys) to achieve simple goals. This is indicative of the problem with students' ICT skills on entering secondary school. The result is that teachers start lessons in Key Stage 3 at a level which can be demotivating for more capable students. A more joined up approach to the primary-secondary transition would help to reduce repetition of work and stop more able students from being switched off computing in the early years of Key Stage 3.

Although provision for programming is already in place in the Key Stage 3 curriculum as 'sequencing and structures', more emphasis should be put on programming throughout the early stages of the ICT curriculum. This would help make students more aware of what they will meet in the computing options at KS4 and in sixth-form.

The current ICT curriculum is appropriate to deliver the 'ICT literacy' skills students require to be effective users of today's technology. However, the main barrier to the curriculum achieving this goal is the lack of specialist teachers in schools. Without a specialist background or regular continuing professional development (CPD) teachers lack the confidence to interpret the curriculum and develop their own programme of study to teach the subject in interesting ways best-suited to their students.

Teachers have welcomed the removal of assessment at Key Stage 3, which has freed them up to innovate in the design of their lessons. However, assessment criteria for Key Stages 4 and 5 continue to constrain these curricula and the teaching that goes on in the classroom. The assessment models need to widen to allow, for example, multiple programs to be used as part of a broader curriculum in which teachers can innovate in the classroom at all levels.

Teachers consider computing as a clearly defined discipline while the ICT curriculum provides students with a basic set of skills to use ICT technologies, which in some cases can focus on a very narrow set of office-related programs. The computing curriculum at Key Stage 4 was considered not to equip students with an understanding of the core principles and thinking skills which underpin computing. A curriculum with a focus on delivering the core computing skills, which are independent of available hardware or software would reduce the need to revisit topics as new technologies are adopted – given the current rate of technological advance this can occur during a student's period of study in secondary school.

The ICT curriculum would be improved by introducing more relevant and interesting real-world contexts through which the core principles and skills of ICT are covered. There is evidence of such good practice in schools which has led to improved results both in students' achievement levels and enthusiasm for ICT/computing. Specialist ICT teachers are more effective at identifying and introducing such themes in their programmes of study.

To deliver effectively any updates or improvements to the curriculum teachers will need to be supported with readily available teaching resources set at appropriate levels (foundation, intermediate, higher) and based on themes that are appealing to students (*eg* games, Facebook *etc*). A set of resources similar to the MyMaths package would help facilitate delivery of ICT/computing in schools.

According to the delegates, young people are bored with ICT as a subject. Many of the factors contributing to this loss of interest are mentioned above: the lack of specialist teachers; the repetition of work and topics in the early stages of KS3; and an assessment model that restricts teachers' innovation in the classroom. In addition, the low status of ICT/computing as an academic or vocational subject with senior management is as significant issue that needs to be addressed. Senior management's perception of computing has allowed a culture of non-specialist teachers teaching the subject to develop, which would not be tolerated in other subjects. Head teachers might be made to give greater consideration to the subject's status and needs if, for example, the study of computing is made compulsory up to 16 or included in the proposed English Baccalaureate.

Finally, the bewildering range of qualifications in ICT and computing does not help matters. There is concern that a Government focus on performance league tables will lead head teachers to switch to ICT/computing qualifications that improve school performance in league tables, but do not best support student progression onto further study in computing.

Discussion 2: Resourcing, staffing and training issues in delivering computing

This discussion focused on the lack of teachers with a computing specialism working in schools and approaches to improve the supply of specialist teachers. Delegates also gave their views on the types and deliver of CPD courses for computing teachers as well as how the IT infrastructre should develop in schools in the future.

There are not enough specialists teaching ICT/computing in schools. Teachers identify two types of specialists: those with a computing qualification; and those with extensive experience of teaching ICT/computing. The low status of the subject with senior management, which has led to a non-specialist approach to become acceptable in schools, has not helped the issue of recruitment and retention. Teacher trainers report difficulties in recruiting teachers onto a PGCE or ITT course to teach ICT up to 16. The recruitment of trainees to teach computing is an even more serious issue. Possible solutions to the problem of recruitment and retention suggested in the discussions include:

- running conversion courses to computing from other degree subjects for graduate teachers;
- running university outreach programmes where undergraduates on computing courses visit schools to support teachers and find out more about teaching as a career;
- mentoring programmes in which experienced ICT/computing teachers support NQTs and career-change teachers;
- encouraging teacher trainers to incorporate more computing in their PGCE courses.

The issue of recruitment and retention of specialist ICT/computing teachers is not expected to improve. Cuts to the number of places on PGCE computing courses and the removal of the £9k bursary for trainees are likely to make recruiting candidates, with or without a specialism in computing, to train as ICT/computing teachers more difficult. In future, industry should be encouraged to support/sponsor trainee computing teachers. Also, if there is a lack of specialist ICT/computing teachers across the UK, one outcome of this is that the ones that do exist will be concentrated in selective or grammar schools

On the issue of training, teachers agree that subject-specific CPD helps to develop their confidence in the teaching of computing. Teachers also require more frequent CPD in ICT/computing because of the pace of advances in technologies. [Although there is a core of 'computational thinking' that will not change over time.] However, teachers' preferences for the timing and nature of CPD courses are mixed. Out of school CPD days are more valued by teachers but the associated costs (course cost, staff cover) and limited school budgets prohibit teachers from attending these courses. Delivery of CPD courses more local to schools would be an advantage. Could this be achieved by reviewing good existing courses (*eg* provided by CAS in London) and then designing and developing courses that can be disseminated and run in local regions? Teachers and senior management should be looking ahead and planning what CPD is required and how best to accommodate this into teaching schedules and to budget for the courses and any required staff cover.

Extra-curricula activities such as after-school computing clubs play an important role in inspiring and enthusing students about the subject. ICT/computing teachers should look to build links with STEM partners and industry to run these types of activities. For example, linking up with D&T colleagues in schools to offer more rounded activities which incorporate computing. This discussion prompted the questions:

- Do teachers in schools need help and training on how to set up, structure, run and maintain after school clubs?
- Can university admissions tutors be encouraged to include hobby/extra-curricula computing activities as a feature of their lists of preferred requirements for applicants to STEM degrees?

Finally, in the view of teachers the future of ICT/computing infrastructure in schools should be based on virtualisation. This technology avoids the difficulties some teachers experience when trying to have new software installed in schools. Can a working group, involving professional bodies, CAS, BCS, be set up to investigate how best to educate senior management and teachers about this technology and promote its roll-out in schools across the UK?

Discussion 3: Making the case (to school management, pupils, parents) for computing

In this final session delegates concluded that computing and ICT are misunderstood by learners, teachers and head teachers, and that this gives rise to a poor perception of the subject in schools. Possible approaches to address this issue include the provision of more fun activities based on competing, better information advice and guidance for students (and their parents) and a re-branding of computing in schools.

In general students, parents and school management do not understand the difference between ICT and computing. If students have a poor ICT learning experience in KS3, this misunderstanding leads to a poor perception of computing and puts young people off studying the subject at KS4 and beyond. Girls' perception of computing is a particular issue that needs attention. The ICT/computing community must communicate to students, parents, school management and other stakeholders such as HE admissions tutors, that computing has both academic rigour and challenge as well as vocational application.

Poor perceptions of computing, and confusion over the terms 'ICT' and 'computing', might be counteracted by creating a continuum of discrete specialised computing experiences in the curriculum from Key Stages 1 to 3. Running more computing competitions in schools, such IBM's BlueFusion and LegoRobotics competitions, would help to expose students to more specific computing skills. Extra-curricula activities also have a role to play here. Other types of experiences that will help students to have a better understanding of computing and to make informed decisions about computing options at Key Stages 4 and 5 include:

- offering taster sessions on A-level computing in Years 10 and 11.
- inviting groups from outside school to show students the exciting opportunities computing offers. A good example is the computing magic show run by Queen Mary's College, University of London;
- 'boot camps' for computing, which students would elect to follow as an alternative to work experience;
- mobilising computer science undergraduates to go into local schools. TeachFirst is working with universities to develop and include a module in second/third year of computer science degrees in which students visit local schools to deliver computing sessions and get experience of teaching computing as a career.

To promote computing as a viable subject for gifted and talented students, teachers need to show that the course will support students' progression to study in HE. There is evidence that computing is valued by HE admissions tutors for STEM degrees but this needs to be communicated more clearly. Can HE admissions tutors be encouraged to include computing as a preferred subject in the information, advice and guidance (IAG) for applicants to STEM degree courses?

More impartial careers resources need to be designed to let students know how computing can help them progress along their desired career pathway. These should be easy for students to access, *eg* a YouTube channel with episodes on particular careers and interviews with workers. Also include more computer science-based profiles on the national STEM programme's Futuremorph website.

Delegates suggested an effective route to influencing school management on computing provision in schools would be for CAS and BCS members to take on school governors at local schools.

A re-branding of ICT and computing with a new name that reflects the broad scope of IT technologies and applications in the 21st century might improve the subject's standing in schools. Suggestions included Innovation and Computational Thinking; Innovation and Technology (IT), Informatics.

In a utopian world...

To conclude the event, delegates were asked to offer their visions of how, in a utopian world, computing should be structured and delivered in schools. In one vision ICT/computing would be recognised as being made up of three components: functional skills (office and design); societal and ethical issues (to use ICT skills effectively); and computing. The functional component would be delivered through a cross-curricula approach so that this element is taught in context and makes sense to students. This would still end in some form of formal assessment and contribute to a discrete qualification. It is likely that the societal and computing elements would be offered as options in later years in schools. There are, however, constraints to this vision. Will other subject teachers have enough knowledge to deliver the cross-curricula aspect? A successful cross-curricula model can be expensive to implement. How can schools learn or benefit from other schools' successes in this area? This would require the dissemination of good practice.

An alternate vision would have more specific requirements relating to computing set out in the National Curriculum criteria, *eg* students must have digital arts skills/experience and must be competent in programming. This could then be delivered through ICT as a discrete subject or a cross-curricula approach.

The third vision would promote a teaching method which focuses on empowering students to direct lesson activities. This approach encourages students to use their skills effectively and imaginatively. However, such practice does require teachers to know that students have developed the required skills in the previous Key Stage. Teachers must also have the confidence to allow students to do this and to recognise a good result by students. For this vision to be a success appropriate CPD courses would need to be available to teachers.

Participants:

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Caroline Croydon (Felsted School)
Gary Owen (Tonbridge Grammar School)
James Franklin (Chichester High School for Boys)
Sean Byrne (OCR)
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